

TABLE 65.—*Willemstad, Curacao**

	Length of record, years	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Temperature														
Mean maximum.....	15	83.1	83.5	83.5	85.1	86.0	86.9	86.7	87.3	87.8	86.9	85.6	83.4	85.5
Mean minimum.....	15	74.5	74.5	74.5	76.3	77.7	78.1	77.7	77.7	78.3	77.7	76.6	75.2	76.6
Mean.....	15	78.8	79.0	79.0	80.7	81.8	82.5	82.2	82.5	83.0	82.3	81.1	79.3	81.0
Highest.....	15	85	87	86	92	90	93	90	91	94	91	90	89	94
Lowest.....	15	68	68	67	70	73	72	72	71	70	70	70	69	67
Relative humidity														
Mean, 8 a., 2 p., 8 p., (?).....	15	77	75	76	76	77	77	78	78	78	78	79	79	77
Cloudiness														
Mean, 3 observations.....	15	4.7	4.9	4.4	4.9	4.5	4.7	4.4	4.1	4.4	4.8	4.9	4.8	4.6
Precipitation														
Mean.....	70	2.07	0.95	0.84	1.07	0.76	0.95	1.47	1.22	1.12	4.20	4.43	3.85	22.93

* Data from the *Encyclopaedia van Nederlandsch West Indie*.TABLE 66.—*Mean precipitation (in inches), Dutch West Indies**

Stations	Length of record, years	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Curacao														
Groot St. Joris.....	17	2.07	1.54	0.85	1.16	0.47	0.63	0.98	0.89	0.95	4.02	4.79	3.05	21.40
Hoffie Abau.....	13	3.61	2.08	1.13	0.87	0.36	0.85	1.11	1.10	1.76	4.72	5.86	3.37	26.84
Willemstad.....	70	2.07	0.95	0.84	1.07	0.76	0.95	1.47	1.22	1.12	4.20	4.43	3.85	22.93
Bonaire														
Kralendyk.....	20	2.28	1.15	0.71	0.65	0.52	0.57	1.13	1.03	1.04	3.10	4.14	3.53	19.95
Aruba														
Oranjestad.....	24	2.01	0.58	0.66	0.64	0.38	0.53	0.97	1.03	1.28	2.92	3.43	2.98	17.41

* Data from *Meteorologische Waarnemingen, Suriname en Curacao*.

PRECIPITATION VERSUS SNOW SURVEYS FOR PREDICTING STREAM DISCHARGE

551.577 : 551.578.46 :
627.41 (792)

By J. CECIL ALTER

[U. S. Weather Bureau, Salt Lake City, Utah]

[Read before Utah Academy of Sciences, Salt Lake City, Utah, Saturday, April 3, 1926]

This paper is the result of an inquiry as to the comparative value of precipitation records and snow surveys for predicting the flood-time discharge of Big Cottonwood Creek, one of the major sources of Salt Lake City's water supply. The inquiry has resulted rather decidedly in favor of precipitation records where they are available in proper numbers and places, though the snow survey shows a valuable correlation factor.

Big Cottonwood watershed, discharging into the Salt Lake valley about 12 miles southeast of Salt Lake City, is about 12 miles long and about 48.5 square miles in extent, its sharp crest lines being from 9,000 to 11,000 feet above the sea. Thus the watershed has appeared to be an excellent region for successful snow survey work. These have been made with encouraging results since 1912 by the Salt Lake City engineering and water works departments.

The results of a preliminary inquiry into the subject of precipitation vs. snow surveys were presented before this Academy a year ago. The surveys, as of the close of April, reduced to percentages of the mean for the period were compared with the stream discharge from May to August, inclusive, a period in which run-off averages about 40,000 acre feet or two-thirds of the annual discharge.

The difference between snow survey percentages (using the densities or water-content values) and stream discharge percentages averaged 13.4 per cent for the period 1912 to 1917 inclusive, utilizing from 60 to 100

SWAN ISLAND

This small island lies in the western Caribbean Sea about 100 miles off the coast of Honduras (17° 24' N., 83° 17' W.; elevation, 35 feet).

The mean annual temperature (80.5°) is 1.5° higher than that for the eastern stations of Christiansted and Basseterre in the same latitude, and is very slightly lower than the high mean noted for Willemstad. The range in temperature is from 92° to 64°, practically the same as observed for the greater part of the West Indian region.

The mean annual rainfall is about the same as that near sea level on the islands of St. Croix, St. Kitts, and Antigua—51 inches.

TABLE 67.—*Swan Island*

	Length of record, years	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Temperature														
Mean maximum.....	8	82.9	83.4	85.0	86.3	87.6	86.3	87.0	87.8	87.7	86.8	85.0	83.9	85.8
Mean minimum.....	8	72.8	73.1	73.7	75.3	76.7	76.3	76.7	76.6	76.6	75.8	74.9	73.8	75.2
Mean.....	8	77.8	78.2	79.4	80.8	82.2	81.3	81.8	82.2	82.2	81.3	80.0	78.8	80.5
Highest.....	8	88	86	89	90	92	92	91	91	91	90	89	88	92
Lowest.....	8	64	66	67	68	68	70	70	70	70	70	70	69	64
Precipitation														
Mean.....	10	3.28	1.35	1.45	0.98	2.12	8.04	4.53	4.27	4.25	7.91	8.73	4.22	51.13
Maximum in 24 hours.....	10	2.50	1.03	2.54	1.97	3.08	4.90	4.86	3.01	3.32	4.42	5.54	4.10	5.64
Days with rain.....	10	12	8	6	4	7	16	12	13	13	17	16	15	139

measurements distributed fairly generally over the watershed. But for about 25 measurements in Brighton basin, 6.8 square miles in extent, at the head of the canyon, the survey figures differed from the discharges by an average of only 11.5 per cent from 1912 to 1924; while sets of readings in 6 selected places differed 12.5 per cent from the discharge figures; and measurements at only two of these places varied only 12.3 per cent from the discharges. Some of this variation is doubtless due to the differing lengths of the records. It was also shown that the simple snow depth values in Brighton Basin gave an average miss of only 13.3 per cent a somewhat surprising value in view of the general belief that snow densities vary greatly. They probably do not vary greatly at the end of April, by which time the texture of the snow layer has apparently become comparatively homogenous.

The coefficient of correlation for the values of best fit given above (11.5%) was found to be 0.841 plus or minus 0.055, a very good correlation.

A considerable effort has been made by various investigators to discover a relationship between precipitation and stream flow, on the basis of records at the several cooperative weather stations in the general neighborhood of the Cottonwood Canyons. Results have in general been only fair; whence the usual conclusion that the stations are not in correct positions to serve best as indicators, and possibly not numerous enough.

To overcome some of these defects in the present inquiry the precipitation records have been weighted to accentuate the favorable and to diminish the unfavorable aspects of location; and the investigated group has been enlarged to include several stations not on the watersheds, to correct the defect of dearth of records as far as possible. Furthermore, of the available precipitation records, only selected months were used, rather than the calendar or any other year, having in mind always that the group or unit should serve only as an indicator.

The results shown herein are from precipitation for October to April just preceding the May to August discharge period. The precipitation stations finally used (with their altitudes and average annual precipitation in inches for general information), are as follows: Silver Lake in Brighton Basin, 8,700 feet above sea level, 43 inches annual precipitation; Cottonwood Weir in the mouth of Big Cottonwood Canyon, 4,992 and 22; Lower Mill Creek, about 4 miles south of Cottonwood Weir, 4,959 and 23; Salt Lake City, 4,408 and 16; Midvale 12 miles south of Salt Lake City, 4,365 and 16; Snake Creek, 6 miles southeast of Silver Lake and beyond a high divide, 5,950 and 24; and Heber about 12 miles southeast of Silver Lake, 5,593 and 17. Only Silver Lake and Cottonwood Weir are on the watershed.

Employing precipitation group No. 2 (Silver Lake, 3 times Snake Creek, and 4 times Heber) as a unit for the 10 years of concurrent record, and reducing it to percentages for comparing with the percentages of discharge for the same period, the average deviation was found to be only 6.5 per cent. Precisely the same average deviation was shown by the use of precipitation group No. 5 (Salt Lake City, Silver Lake, 2 times Cottonwood Weir, 5 times Snake Creek, and 6 times Heber) for 8 years of concurrent record.

But testing the relationship by the use of a more trustworthy method, from the original precipitation and stream discharge data, the correlation coefficient for group No. 2, 10 years, was found to be 0.914 plus or minus 0.035; and for group No. 5, 0.979 plus or minus 0.010. The latter is a rather remarkable correlation, due in part probably to chance in so short a record. The original snow survey data for this same 8-year period shows a correlation coefficient of 0.683 plus or minus 0.127, not very satisfactory, though it probably would be improved by a longer record.

Precipitation records as indicators of stream discharge are also very valuable because they apply to other nearby watersheds to a certain extent. For instance, precipitation group No. 2, 10 years, paralleled with the combined original data for the discharge of the two Cottonwood streams, gives a correlation coefficient of 0.921 plus or minus 0.032; while the Brighton Basin snow survey original data gave a correlation coefficient of only 0.608 plus or minus 0.134, when paired with Big and Little Cottonwood Creeks combined.

Similarly, precipitation group No. 5, 8 years, shows a correlation coefficient with the two Cottonwoods combined of plus 0.950 (± 0.023); while the snow-survey correlation coefficient for the same period is only 0.493 plus or minus 0.180. This has practically no predictive value, though it may be due in part to the shortness of record available.

It will not be forgotten that snow measurement sites or stations, like precipitation stations, should be regarded as indicators only; though where their locations are suitable, very good results may be obtained. Furthermore, where there is a scarcity of precipitation records or the tenure of precipitation stations is insecure, the snow survey is, in most watersheds, a convenient and satisfactory substitute.

WHIRLWINDS AT OIL-TANK FIRE, SAN LUIS OBISPO, CALIF.

551.515:(794)

By J. E. HISSONG

614.481

[U. S. Weather Bureau Office, San Luis Obispo, Calif., April 17, 1926]

On the morning of April 7, 1926, following a showery night, several mild lightning discharges were noticed in the south, the first at 7:15 a. m., followed by rumbling of thunder in the distance. At 7:35 a. m. a very intense discharge of lightning occurred accompanied by a crash of thunder; this was followed instantly by a terrific explosion that shook the town of San Luis Obispo severely. About 20 large plate-glass windows in store fronts were completely shattered, numerous small windows in residences were broken, houses rocked on their foundations and hundreds of people rushed into the streets, many under the impression that a severe earthquake shock had occurred. The lightning bolt had struck the large oil reservoirs at the tank farm of the Union Oil Co., located about $2\frac{1}{2}$ miles directly south of the center of the town, and the oil, or the vapor in or over three of the reservoirs had exploded, setting them on fire. These reservoirs have a capacity of 750,000 barrels and were full.

An employee of the oil company, who was looking toward the reservoirs at the time of the explosion, said: "I saw two balls of lightning strike reservoirs No. 5 and No. 7; a clap of thunder and an explosion followed immediately and the tanks burst into flames. At the same time the earth rocked so violently under my feet that I was almost thrown down."

A fourth reservoir was fired and exploded about 15 minutes later. Testimony as to the cause of the explo-

sion of this reservoir is conflicting. An inspector for the oil company reported that it was struck by another lightning discharge. Others in the vicinity say that the first explosion threw burning timbers from the roofs of the exploded reservoirs, and possibly burning oil, on the fourth reservoir, causing it to explode.

Approximately 6,000,000 barrels of oil was stored at the farm in concrete reservoirs and steel tanks. With the exception of five of the smaller steel tanks, containing about 250,000 barrels of oil, all the oil burned during the five days of the fire.

Typical thunderstorm conditions prevailed at San Luis Obispo during the morning of the 7th. A storm which had been developing over the ocean between the California coast and the Hawaiian Islands for several days had increased in intensity and moved northeastward during the night. Its center on the morning of the 7th was approximately 600 miles west of San Francisco, the lowest barometer reading near the center being close to 29.00 inches. The thunderstorm was, therefore, about 700 miles southeast of the center of the low-pressure area. A moderate southeast wind had prevailed during the night and had increased to 18 miles per hour after 5:00 a. m. About 7:20 a. m. the wind changed to southwest, blowing out of the approaching squall, and increased to 24 miles per hour. At the same time a heavy downpour began, 0.18 inch of rain falling in three min-